Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2022/2023

COURSE NAME	:	INSTRUMENTATION & MEASUREMENT
COURSE CODE	:	BEJ 10702
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	FEBRUARY 2023
DURATION	:	2 HOURS
INSTRUCTION	:	1. ANSWER ALL QUESTIONS 2.THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK.** 3.STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 (a) Define sensor and transducer.

(4 marks)

(b) A resistive position transducer with a resistance of 4000Ω and a shaft stroke of $100mm$ is used as shown **Figure Q1(b)(left).** The initial position to be used as a reference point is when $R_1 = R_2$ (i.e, the shaft is at mid stroke, $X = 50mm$ from B). A bridge circuit is used to connect the transducer as shown in **Figure Q1(b)(right)**. Potentiometer R_3R_4 is 4000Ω and $V_T = 4.0V$. At the start of the test, potentiometer R_3R_4 is adjusted so that the bridge is balanced ($V_E = 0$).

(i) If the position is moved at $25mm$ toward A, calculate the new value of V_E.

(4 marks)

(ii) Repeat the same calculation as demonstrated in **Q1(b)(i)**, solve all values given in **Table Q1(b)**.

(5 marks)

(iii) Plot a graph V_E versus X from **Table Q1(b)**.

(3 marks)

(iv) Identify the model of the transducer from **Q1(b)(iii)**.

(1 marks)

(c) A parallel-plate capacitance type transducer has the following specifications:

- The metal plate, A where the width is 4cm and 10cm length.
- The distance, d between the metal plates is 0.5 mm.
- Dielectric constant, k of a ceramic type dielectric material is 1000.
- Vacuum permittivity, ε_0 is 8.854×10^{-12} F/m.

(i) Draw and label the design of parallel-plate capacitance above based on the given specifications.

(4 marks)

(ii) Calculate the capacitance.

(4 marks)

Q2 (a) List **TWO (2)** advantages of Kelvin Double Bridges as compared with Wheatstone Bridge.

(3 marks)

(b) Describe the difference between Hay Bridge and Schering Bridge.

(4 marks)

(c) The Wheatstone Bridge used for measuring temperature is as shown in **Figure Q2(c)**. The Rx is referred to the resistance produce by thermistor during the temperature measurement. The value of Rx is inversely proportional with the change of the temperature. Meanwhile during the measurement, the potential difference is measured from point C to D.

(i) Calculate the value of Rx at balance condition.

(2 marks)

(ii) Calculate the Vout when Rx equal to 1500Ω.

(4 marks)

(d) The Wheatstone Bridge shown in **Figure Q2(d)** is connected to galvanometer (G). The galvanometer has current sensitivity of 50mm/mA and an internal resistance of 300 Ω. Whereas the internal resistance of battery (Vs) is negligible. Calculate the deflection of the galvanometer when Rx = 1800Ω.

(12 marks)

Q3 **Figure Q3** shows a Computer Numerical Control (CNC) machine tool for drilling holes in flat plate.

(a) Explain why rotary encoder is used over linear encoder.

(2 marks)

(b) Choose what type of rotary encoder as a feedback device in the system and give your reason.

(2 marks)

(c) Construct the block diagram/ components to represent the closed loop system.

(6 marks)

(d) The leadscrew of the CNC machine has a pitch of 5 mm and is coupled to the motor shaft with a gear ratio of 5:1 (5 turns of drive motor for each turn of screw). The optical encoder generates 48 pulses/ rev of its output shaft. The table is programmed to move a distance of 250 mm at a speed rate of 500 mm/min. Determine:

(i) The pulses should be received by the control system to verify that the table has moved exactly 250 mm.

(2 marks)

(ii) The pulse rate of the encoder.

(4 marks)

(iii) The drive motor speed that correspond to the specified feed rate.

(4 marks)

(e) List **FIVE (5)** applications of rotary encoder other than CNC machine tool.

(5 marks)

Q4 (a) List **TWO (2)** advantages and **TWO (2)** disadvantages of a digital instrument compared to analog instrument.

(4 marks)

(b) **Figure Q4(b)** shows a circuit for voltage to frequency converter.

(i) Describe the function of a voltage to frequency converter.

(1 marks)

(ii) Given Vi = f /50. Calculate the amplitude input voltage Vi of the voltage to frequency converter, if 600 pulses pass the AND gate during 0.1 seconds gating pulse.

(7 marks)

(c) A Dual-slope Analog-Digital Converter (ADC) consists of an operational amplifier integrator that contains an integrator circuit, a logic control circuit, a counter, a clock, a voltage reference, and basic components.

(i) Sketch the Dual-slope ADC with correct labels.

(5 marks)

(ii) Calculate the value of the resistor if the capacitor of 2μF is used so that the integrator will produce 10V output after 2ms when the measured input voltage is 2V and the initial voltage output is zero.

(4 marks)

(d) A Voltage to frequency Convertor (VFC) consists of a voltage controller oscillator (VCO), a gate pulse generator, and an AND gate. If the output frequency to measured voltage of the VCO is 100. Calculate the measured voltage when 200 pulses are detected during 0.01 seconds.

(4 marks)

-END OF QUESTIONS –

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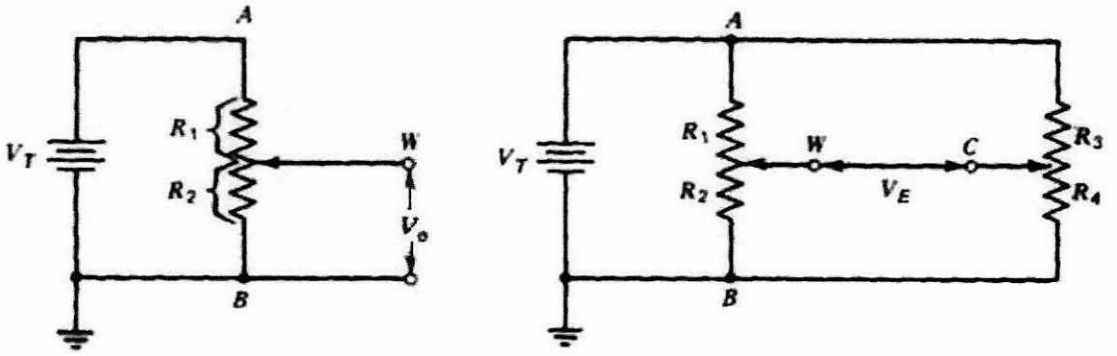

Figure Q1 (b). (left) the transducer, (right) the bridge circuit

Table Q1(b)

X (mm) (B to A)	0	25	50	75	100
$R_1\,\Omega$					
$R_2\,\Omega$					
V_E					

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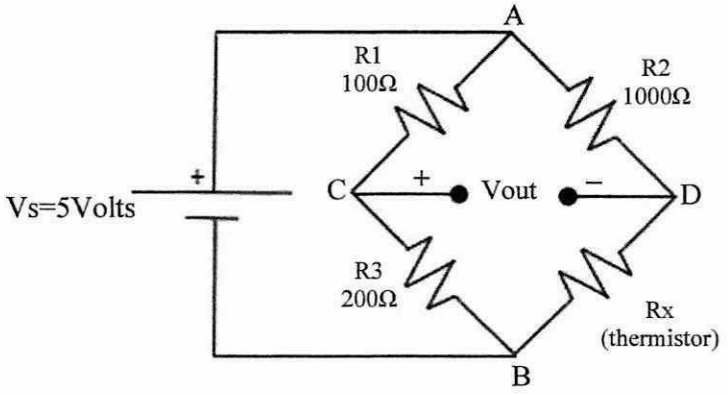

Figure Q2(c)

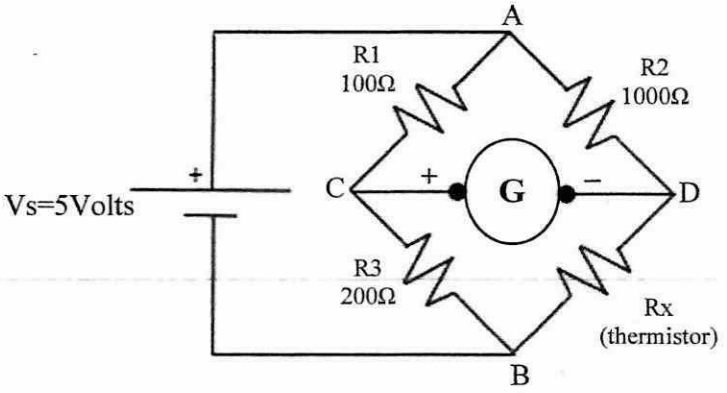

Figure Q2(d)

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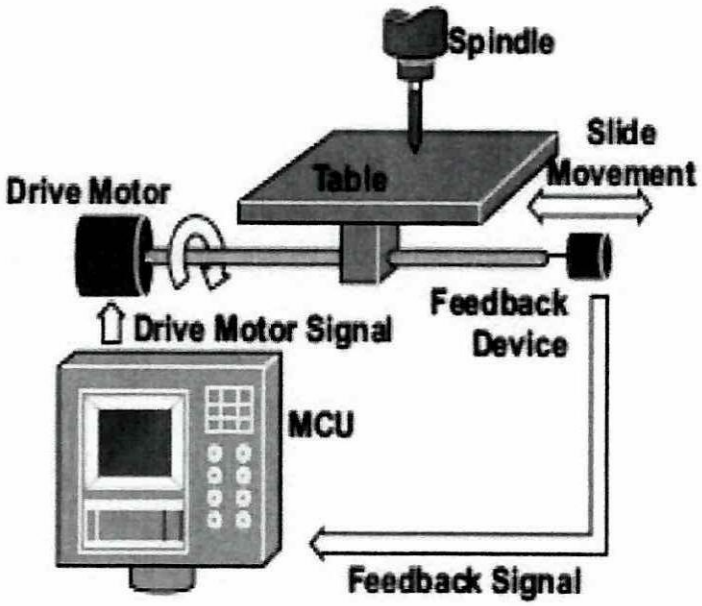

Figure Q3

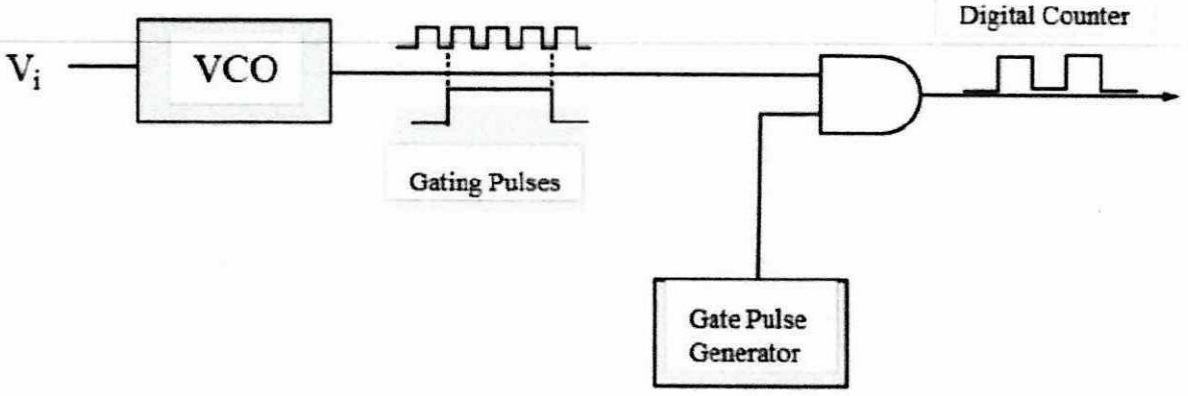

Figure Q4(b)